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Household Energy Efficiency in the UK

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I. ENERGY TAXATION AND ENERGY EFFICIENCY

Over the past three years, policy towards the taxation of energy has been debated vigorously. In 1991 the European Commission proposed a new carbon/energy tax as part of a package of measures intended to reduce energy use and to help the Community meet international targets for reducing emissions of carbon dioxide and other 'greenhouse gases'. This would have applied to both domestic and industrial users of energy and motor fuels. Also, in the area of UK domestic policy, the Chancellor's 1993 Budget announced the phased extension of the standard rate of value added tax to domestic energy, which had hitherto been zero-rated in the UK. The extension of standard-rate VAT to domestic energy was primarily motivated by the need for increased tax revenues, but, at the same time, the Government maintained that the measure would have the valuable by-product of reducing energy consumption, and hence contributing to achievement of targets for reducing greenhouse gas emissions.

One common issue raised by both the proposed EC carbon/energy tax and the extension of VAT to domestic fuel is the likely distributional impact. Domestic energy forms a much larger part of the budgets of poorer households than of those of the population as a whole; Crawford, Smith and Webb (1993) show that

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domestic energy accounts for some 17 per cent of the non-durable spending of the bottom decile, but only 10 per cent of household spending on average. Additional taxes on domestic energy will thus tend to have a regressive distributional incidence,[2] in the sense that the extra energy tax payments will be a higher percentage of income (or of total spending) for poorer households than for the better-off.[3]

In addition to the burden of extra taxation, a second issue has been the distribution of the burden of reductions in energy consumption in response to higher energy prices. It appears likely that the reduction in energy consumption induced by the imposition of VAT on domestic energy will be appreciably greater amongst poorer households; Crawford, Smith and Webb (1993) estimate that the energy spending of the bottom quintile would fall by 9 per cent in volume terms, whilst the average reduction in the volume of energy consumption would be of the order of 6 per cent.

The aggregate economic cost of adjustment to higher energy prices will be higher where energy consumers are prevented by market failures from making optimal adjustments in energy use. An efficient pattern of adjustment to higher energy prices might include both reductions in energy consumption and greater levels of investment in various measures to increase the efficiency with which energy is used. In the domestic sector, measures that households can take to improve domestic energy efficiency may include such things as loft insulation, double glazing and wall insulation. It has been suggested that markets for these investments may be subject to various forms of market failure, possibly including credit market failures, informational failures and certain market failures related to housing tenure. Where households are prevented by market failures from adjusting efficiently to higher energy prices, their reductions in energy consumption in response to higher energy prices will tend to be smaller, and more 'painful' in terms of their welfare cost.

The social and distributional costs of higher energy prices may be exacerbated if market failures in energy efficiency investment are particularly concentrated amongst low-income households or other vulnerable groups (Smith, 1992). Thus, for example, income-related market failures, such as those related to the credit market or to housing tenure, may tend to amplify the distributional cost of reducing energy consumption through pricing instruments. Measures to rectify the underlying market failures would then have the twin merits that they would tend to reduce the aggregate economic cost of achieving a given reduction

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[2] However, once the use of the additional revenues from energy taxation is considered, a revenue-neutral package of measures, including higher energy taxes combined with higher transfers to poorer households, could be designed which, overall, would on average leave poorer households better off (Johnson, McKay and Smith, 1990).

[3] Smith (1992) shows that in the UK the EC's carbon tax would be likely to have a regressive distributional impact too; the regressive effect of higher taxation of domestic energy would outweigh the progressive distributional incidence of higher taxes on motor fuels.

in consumption, and at the same time would also help to reduce the social and distributional cost of higher energy taxation.

Policies to promote greater energy efficiency have been pursued by many governments in the OECD area since the oil shocks of the 1970s, initially for balance-of-payments reasons. A range of policy interventions have been used, including financial incentives through taxes and subsidies, policies to improve the information available to private decision-makers, and building regulations (Brechling, Helm and Smith, 1991). More recently, attention has shifted to the potential contribution of these policy measures to environmental policy objectives, both directly, through the reductions in energy consumption that might follow an increase in energy efficiency, and indirectly, by reducing the cost of adjustments to higher energy prices as outlined above. It has been suggested that some energy efficiency policies may constitute 'no regrets' measures: by correcting market failures that inhibit energy efficiency investment by individual households, they may improve the functioning of the economy, regardless of whether reduced energy use confers any future environmental benefits.

The belief that market failures must be important has been reinforced by studies, based on technical data, which show substantial rates of return to investments in domestic energy efficiency in typical properties. For example, Pezzey (1984) estimated that the net present value per unit of capital cost of loft insulation was of the order of 3.5–7.5, and of cavity wall insulation between 1.8 and 4.7. Installing double glazing, by contrast, appeared to be unjustified on grounds of energy saving.[4] Although the proportion of the UK housing stock with each measure has been rising over time (Figure 1), it is suggested that the fact that so many households still have not taken these measures may reflect various market failures.

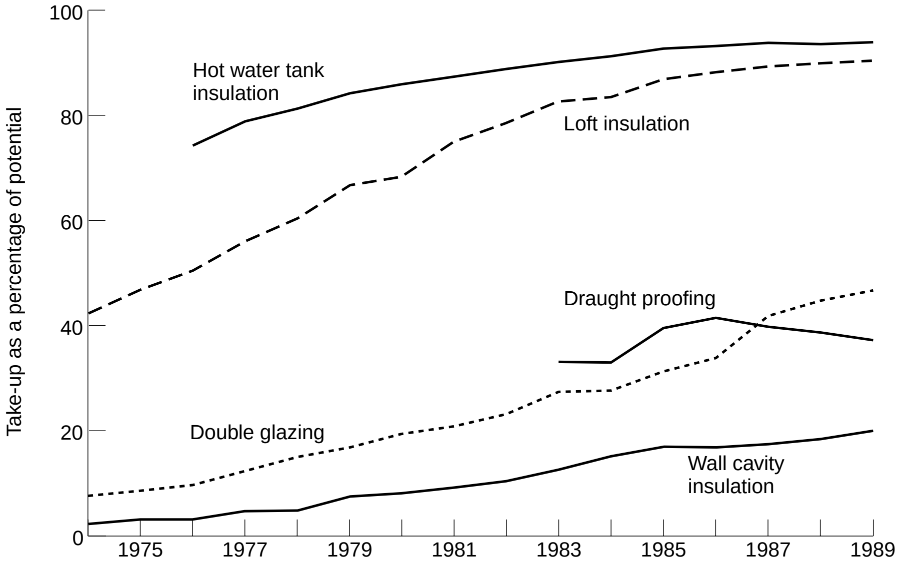
Nevertheless, despite the role that such arguments have played in the formulation of policy, evidence about the practical importance of market failures in domestic energy efficiency is lacking. This paper provides evidence on the pattern of energy efficiency investments amongst private households in the UK, based on economic modelling. The results provide some pointers to the relative significance of some forms of market failures in energy efficiency investments.

The plan of the remainder of the paper is as follows. Section II discusses various forms of market failure which could arise in the energy efficiency sector. Section III reports an empirical study of factors affecting household take-up of energy efficiency measures. Section IV draws some brief conclusions about the policy implications of the results.

[4] The calculated returns to energy-saving investments will depend on the assumptions made about future energy prices; as a result of the fall in real energy prices during the past decade, the returns to energy efficiency measures are likely to be now somewhat lower than during the early 1980s.

FIGURE 1

Percentages of Housing Stock in England with Energy Efficiency Measures



Note: The figures are calculated as the percentage of the housing stock in which it would be possible to install the energy efficiency measure concerned.
Source: Henderson and Shorrock, 1989.

II. DOMESTIC ENERGY EFFICIENCY DECISIONS

The main focus of the paper is on the actions households can take to prevent energy loss from energy-using activities, principally domestic space and water heating, through various energy efficiency investments, including loft insulation, wall insulation and double glazing. In each case, the energy efficiency measures have the character of investments; money spent on them in one year yields benefits over a number of subsequent years.

The demand both for energy and for energy efficiency investments is a derived demand (Hausman, 1979); consumers seek energy services, in the forms of heat, light or power, from a combination of energy inputs (electricity, gas etc.) and capital investments. The choice of how to meet any given demand for energy services will reflect the costs of energy inputs and insulation, and the efficiency with which they are transformed into energy services. In some cases (open fires, and double glazing, perhaps) consumers may derive utility from how the chosen level of energy services is achieved, but usually consumer choices will simply reflect the relative costs of energy and insulation inputs in supplying the chosen level of energy services.

Market failures arising from a number of sources could, however, prevent households from choosing an optimal mix of energy consumption and investments in energy efficiency (Jochem and Gruber, 1990; Brechling, Helm and Smith, 1991):

- *Information*
  Some consumers may fail to undertake cost-effective measures because they are poorly informed about the technological possibilities for energy efficiency investments and about the likely impact of such investments on their fuel use and costs.
- *Benefits cannot be appropriated*
  Cost-effective investments may not be undertaken if the investor cannot appropriate the subsequent energy savings. Owner-occupiers who expect to move at some time in the future may not be able to recoup the full value of investment in energy efficiency through a higher sale price.[5] Also, there may be problems in tenanted housing, where the landlord may be responsible for making any structural improvements that would reduce energy use, but where tenants pay the energy bills. Although, in principle, a higher level of rents could be charged to reflect the benefits of greater energy efficiency, this may be prevented by rent control legislation or if tenants are unable to observe accurately the energy efficiency of the dwelling.
- *Credit market failure*
  Poorer households tend to be less energy efficient (Boardman, 1991). However, it is not clear whether poverty as such, or other characteristics of the household (such as low energy use or tenure), should be seen as the underlying reason for this. One possible source of low rates of energy efficiency investments amongst poorer households could be credit market failures. Poorer households, and other groups of the population with limited collateral, may be severely restricted in their access to credit at the market rate of interest (see, for example, Weber (1990)).
- *Uncertainty*
  Uncertainty may be a source of market failure in household investment decisions, where households are unable adequately to insure against future risks. In the present context, such risks could arise from uncertainty about the effectiveness of particular measures, about the household's future circumstances and energy needs, or about the future energy price.

In addition to the above, household decisions about energy efficiency may be influenced by a wide range of subjective considerations and other non-pecuniary

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[5] Laquatra (1986) examines whether housing markets in the US fully capitalise the benefits of energy efficiency into house prices.

costs. The choices made by individual households are unlikely to be determined simply by the results of an optimising calculation of the installation costs and potential benefits from energy efficiency investments. Consumers may rely on inappropriate decision rules, and may make mistakes. There is also survey evidence that attitudes and other subjective factors significantly affect the diffusion of energy efficiency measures (Hedges, 1991).

III. THE EMPIRICAL ANALYSIS

This section summarises an analysis of the pattern of household take-up of energy efficiency measures; more detail of the analysis is given in Brechling and Smith (1992). This study used data from the 1986 English House Condition Survey (EHCS) to model the pattern of take-up of three key energy efficiency measures — loft insulation, wall insulation and double glazing — by a sample of nearly 7,000 households in England.[6] This data set was particularly suited to examining the interaction between energy efficiency decisions and the socio-economic factors likely to reflect market failures, in that it included data on specific physical features of the dwelling, socio-economic data about the current occupants, and, for a sub- sample of the data, fuel consumption information from both gas and electricity board records.

Table 1 reports logit reduced-form models which explain household possession of each of the three energy efficiency measures — loft insulation, cavity wall insulation and double glazing — as a function of the features of the property and of the socio-economic and demographic characteristics of its current occupants. Each model excludes households that are unable to install the measure concerned; thus, in modelling loft insulation, households without lofts have been omitted. ‘Don’t Know’ replies have also been excluded.

To give an indication of the strength of the effects of the various variables in the estimated models, we show in Table 2 how predicted probabilities of possession, based on the estimated models, vary with changes in household characteristics (income, tenure etc.).

1. Loft Insulation

The first pair of columns in Table 1 report the reduced form for loft insulation. Fourteen of the explanatory variables are found to be significant at the 5 per cent level.

Many of the significant variables describe the physical characteristics of the dwelling. The most obvious interpretation of these variables is that they reflect differences in the cost of undertaking a particular measure. In general, the signs

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[6] We are grateful to the Department of the Environment for providing us with the data, and to Richard Moore for his work in preparing the data for us, and advising on its structure and interpretation. The use we have made of the data, any errors in our work, and our interpretation of the results are our responsibility alone.

of the physical variables are consistent with this interpretation. Dwelling size, for example, tends to be negatively related to the probability of ownership of both loft and wall insulation.

TABLE 1

Logit Reduced-Form Models of the Possession of Three Energy Efficiency Measures

	Loft insulation		*Wall insulation*		*Double glazing*		*Mean (double glazing sample)*
	Co-efficient	Standard error	Co-efficient	Standard error	Co-efficient	Standard error	
Constant	0.24	0.87	–4.55	0.94**	–4.49	0.71**	1.00
Perimeter of dwelling	–0.25	0.07**	–0.10	0.05**	0.11	0.05**	10.21
Area of dwelling	0.006	0.002**	0.002	0.002	–0.003	0.002*	110.77
Semi-detached	0.03	0.14	–0.56	0.12**	–0.16	0.10	0.30
Terraced	–0.28	0.15*	–0.71	0.14**	–0.51	0.11**	0.39
Flat	–0.98	0.20**	–1.16	0.21**	–0.59	0.15**	0.16
Built 1900–18	0.22	0.13*	–0.22	0.18	0.01	0.11	0.11
Built 1919–44	0.50	0.12**	0.02	0.13	0.70	0.09**	0.28
Built 1945–64	0.97	0.16**	0.56	0.14**	1.00	0.11**	0.19
Built 1965+	0.48	0.19**	0.77	0.15**	1.00	0.13**	0.11
Household income (log)	0.30	0.08**	0.34	0.09**	0.27	0.07**	8.56
Head of household aged 26–39	0.17	0.20	0.14	0.23	0.00	0.16	0.28
Head of household aged 40–59	0.07	0.20	0.24	0.24	0.10	0.16	0.33
Head of household aged 60+	0.09	0.25	0.48	0.27*	0.19	0.21	0.33
Head of household is pensioner	–0.08	0.19	–0.38	0.19**	–0.19	0.15	0.27
Head of household unemployed	0.03	0.24	0.18	0.26	–0.09	0.23	0.03
Head of household unoccupied	0.02	0.19	–0.27	0.24	–0.20	0.19	0.06
Local authority rented	0.06	0.12	–0.10	0.12	–2.24	0.11**	0.31
Private rented	–1.10	0.12**	–0.36	0.20*	–1.38	0.15**	0.10
Central heating	1.12	0.09**	0.58	0.11**	0.78	0.08**	0.64
Main heating fuel: electricity	–0.42	0.13**	–0.08	0.16	0.30	0.11**	0.10
Main heating fuel: other fuel	0.48	0.10**	–0.05	0.11	–0.25	0.09**	0.18
Main heating fuel: shared heating	–1.82	0.72**	–0.24	0.49	–0.28	0.38	0.01
Midlands	–0.14	0.11	–0.03	0.12	–0.004	0.09	0.19
East Anglia	0.00	0.19	0.16	0.19	0.41	0.16**	0.04
South-east	–0.01	0.13	0.25	0.12**	0.63	0.10**	0.14
London	–0.33	0.13**	–0.82	0.18**	0.64	0.10**	0.17
West	0.08	0.14	0.38	0.14**	0.49	0.11**	0.10
Occupiers resident 2–5 years	0.20	0.14	0.13	0.14	0.05	0.11	0.19
Occupiers resident 5–10 years	0.10	0.14	0.46	0.14**	0.27	0.11**	0.18
Occupiers resident 10–20 years	0.40	0.15**	0.30	0.15**	0.47	0.11**	0.20
Occupiers resident 20+ years	0.12	0.15	0.22	0.16	0.27	0.12**	0.24
Likely to move in next two years	–0.05	0.11	–0.14	0.12	–0.10	0.09	0.18
Number of observations	5,271		6,374		6,395		
$chi^2(32)$	765.0		400.8		1,866		
'Pseudo' R^2	0.156		0.090		0.233		
Mean of dependent variable	0.825		0.112		0.316		

** denotes a significance level of 5 per cent.
* denotes a significance level of 10 per cent.

TABLE 2

Predicted Probabilities of having Loft Insulation, Double Glazing and Wall Insulation, for Households with Various Characteristics

	Loft insulation	*Wall insulation*	*Double glazing*
Reference household (owner-occupier; head of household aged 40–59; average household income; northern region; has lived in dwelling for 10–20 years; terraced house, built before 1900; average floorspace; gas central heating)	.90	.11	.36
As reference household, but: half average income	.88	.09	.32
As reference household, but: double dwelling area	.86	.09	.38
As reference household, but: tenants in private rented sector	.75	.08	.12
As reference household, but: flat	.82	.07	.34
As reference household, but: electricity used for heating	.86	.10	.43
As reference household, but: no central heating	.75	.07	.21
As reference household, but: detached house, built 1945–64, in south-east region; household income 50% above average	.97	.40	.84
As reference household, but: private rented flat, no central heating, using electricity for heating; residence length under two years; household income 80% of average	.17	.02	.05

In comparison, most of the socio-economic variables are not significant. This is perhaps not surprising in the case of the ‘short-term’ variables, such as unemployment, since the investment decisions being modelled will usually have occurred some time prior to the survey, and socio-economic variables will only be likely to figure in the results if they show some stability over time. Significant effects are, however, found from two socio-economic variables — tenure and income. Properties occupied by private tenants are found to have lower levels of loft insulation than the base (owner-occupied properties); the difference is statistically significant and sizeable. A statistically significant effect of income is also found, but as Table 2 shows, its quantitative effect on the probability of having loft insulation is very small.

Interpreting the coefficients on these two variables in the reduced-form equations estimated here is difficult; they could reflect either some direct influence of income or tenure on the energy efficiency decision, or an indirect influence, through effects of tenure or income on household demand for energy services, which in turn would affect the returns to energy efficiency investments. The reduced-form models shown here cannot separately identify these two types of effect.[7] To the extent that the significant coefficients on income and tenure reflect the former channel of influence, however, this would tend to indicate the presence of market failures in household energy efficiency investments. Since loft insulation and some other energy efficiency investments are likely to be desired only as a means to achieving a given standard of energy services, and not desired in themselves, we would not expect to find any strong direct effect of socio-economic characteristics on household energy efficiency decisions in an efficiently- functioning market. A direct relationship between energy efficiency decisions and socio-economic characteristics might, however, be encountered where certain types of households (such as low-income households) faced significant market failures.

Large effects are found from the type of heating: loft insulation is more likely amongst households with central heating, and is less likely where households use electricity for heating than where they use gas (the base case). The role of central heating in the loft insulation model may be interpreted in various ways. One interpretation, which reflects the higher rates of return to energy efficiency investments in well-heated houses (Pezzey, 1984), is that the central-heating variable proxies the standard of heating of different houses, and the positive sign on the central-heating variable thus reflects a tendency for households to be more likely to undertake energy efficiency measures where the gains are greater. On the other hand, a relationship between energy efficiency investment and the possession of central heating could also reflect differences in awareness and attitudes to investments; households that have invested in central heating may be better informed than the average or may be the type of households that invest in home improvements more generally.

2. Wall Insulation

Given the large energy savings from wall insulation, the very small percentage of households that actually possess wall insulation (11 per cent in 1986) is perhaps surprising. Also, the variables available appear to explain less of the pattern of ownership of wall insulation than of the other measures, as shown by the ‘pseudo’ R^2s.

As with loft insulation, physical factors play a more important role than socio- economic influences. There is rather more variation by type of house and by region than with loft insulation. The type of heating fuel does not contribute significantly to the explanation of the pattern of wall insulation, although, as in the loft insulation equation, the possession of central heating has a positive and

[7] Brechling and Smith (1992) report an attempt to estimate a ‘structural’ model of energy efficiency investments in which these two effects are separately identified. They argue that the socio-economic variables in the reduced- form models can largely be interpreted as reflecting direct influences on household energy efficiency decisions, rather than indirect effects through socio-economic effects on energy consumption.

significant impact. The probability of having wall insulation is higher amongst more recently-built dwellings than amongst older ones.

The strongly significant negative effect of flats and semi-detached and terraced houses over the base detached house could reflect one of two influences. The ‘need’ for insulation and the individual energy saving for each household may be lower in semi-detached or terraced houses or in flats because they have fewer exposed walls. Alternatively, the lower probability of having wall insulation could arise from decision-making problems associated with the shared ownership of walls: organisation and information problems would tend to increase with the number of households participating in the decision.

An important consideration is that some dwellings may face restricted choices over wall insulation. There are three ways in which walls may be insulated — internal solid insulation, external solid insulation and cavity fill insulation. Of the three, cavity fill is the only type that can be installed without major reconstruction or redecoration of the inner or outer walls, and it therefore tends to be the only cost- efficient method of insulating walls except when other work is needed on the dwelling (Pezzey, 1984). The results in Table 1 report the probabilities of possessing *any* type of insulation, and the sample of households on which estimation is based includes all households, not just those with cavity walls.

The model is therefore based on a sample which includes households that are *unable* to install the main type of wall insulation; this may bias the estimates of the factors affecting the decisions of those households that do face a genuine choice regarding wall insulation. We have therefore estimated a second model, based on a sub-sample of dwellings that we can be reasonably sure will have cavity walls. Whilst many older houses do not have cavity walls, cavity walls have been required by legislation throughout the post-war period; selecting a sample of dwellings built since 1945 will thus select a sample that could install cavity wall insulation.

The results of this exercise are not reported in detail here,[8] since in practice most of the estimated coefficients are quite stable between the two models. A number of the significant coefficients, including the income coefficient, are somewhat larger in the post-1945 model; otherwise, the main difference is that the central-heating dummy has a smaller and less significant coefficient in the post-1945 model. There are slightly fewer significant explanatory variables in the model estimated on the post-1945 sample (partly because of the reduced sample size), but the overall level of explanation of the variation in the data, as measured by the ‘pseudo’ R^2, is slightly higher.

[8] A full account of the model can be found in Brechling and Smith (1992).

3. Double Glazing

The double glazing equation has the highest explanatory power of all of the models in Table 1, with many significant variables. In most cases, the variables have the same sign as for the other insulation measures, but there is a clear difference in the impact of electric heating. Electric heating tended to reduce the probabilities of having loft insulation and wall insulation; in this model, households are more likely to possess double glazing if they use electricity for heating. The model also shows significant regional variation, with positive effects from dummy variables for London and the south-east, perhaps reflecting the investment into home improvements during the housing boom of the 1980s.

The income coefficient reported in Table 1, while significant, is no greater than the income coefficient in the estimates for either loft insulation or wall insulation. This is perhaps surprising, since double glazing may be installed for various reasons other than energy saving (for example, to reduce noise), and the demand for these other attributes of double glazing might have been expected to lead to a greater income elasticity than for the models where decisions reflect the effect of the measure on energy costs alone.

The model shown in Table 1 estimates the probability of having at least one window in the dwelling double glazed. We have also estimated a second model, for double glazing of the entire house. The reason for being interested in this is that partial double glazing could be undertaken for reasons unconnected with energy saving (for example, to cut out the noise of a nearby road), whilst full double glazing is generally an energy efficiency measure. The effects of the various explanatory variables are broadly similar over the two models. Income is no longer a significant variable in the model for full glazing; this partly reflects the reduction in sample size, but would also be consistent with the view that full glazing was undertaken to obtain benefits from reduced future energy costs, whilst partial glazing had more direct benefits, for which demand might be expected to be a positive function of income.

IV. CONCLUSIONS

Arguments about market failure play a key role in justifying government intervention in the market for domestic energy efficiency. Despite this, there has been little available empirical evidence about the practical importance of market failures in energy efficiency which could be used to assess the case for policy measures or to target policy interventions on the most significant sources of market failure. This paper has sought to provide some indications based on economic modelling of factors affecting the pattern of possession of energy efficiency investments amongst UK households.

The paper has described the results of an analysis using cross-sectional data from the 1986 English House Condition Survey to assess the role of economic factors in contributing to the pattern of household take-up of energy efficiency measures. Reduced-form logit models have been estimated of the factors influencing the pattern of possession of the three principal energy efficiency measures — loft insulation, wall insulation and double glazing.

The results appear to be consistent with the view that there are certain areas in which market failures may deter households from making rational decisions regarding energy efficiency investments. In particular, there appears to be a strong tenure effect on the pattern of each of the three measures, with rates of possession much lower in private rented properties than in owner-occupied properties. This suggests that policies to reduce market failures in energy efficiency could usefully pay attention to the role of tenure-related market failures — especially to those relating to the private rented sector.

The very much lower rates of energy efficiency investment in private rented properties than elsewhere may reflect the problems arising from the different interests of landlord and tenant; for example, if the landlord is responsible for investing in energy efficiency improvements, whilst the tenant is responsible for energy bills, landlords will only face efficient incentives for making investments if they can recoup the benefit through subsequent higher rents. Rent control legislation may impede rent adjustments of this sort; however, more fundamentally, there may be an asymmetry of information between landlord and tenant about the value of the measures installed which would prevent energy efficiency investments being fully reflected in rent levels, even in a completely free market. It may be possible to devise schemes (along the lines of the 'home energy rating' schemes currently mainly directed at owner-occupiers) that would improve the quality of information available to private tenants about the likely energy costs of a property. Realistically, however, better provision of information is only likely to go part of the way towards eliminating the problems in the private rented sector, and other measures, including both subsidy and regulatory mandation, may be needed if energy efficiency levels in the private rented sector are to be brought closer to the levels in the rest of the housing stock.

In comparison with the strong role played by housing tenure in domestic energy efficiency decisions, there appears to be less indication of any major income-related market failure. This probably suggests that credit constraints amongst poorer households are unlikely to have been a major factor inhibiting energy efficiency investments, and that policies directed at credit market failures in the area of domestic energy efficiency should therefore be a low priority for policy. However, this strong conclusion is subject to two significant qualifications. First, as observed above, the income and other household characteristics relevant at the time of the insulation decision may differ from the

income of the household observed at the time of the survey. Second, the observed pattern of possession of energy efficiency measures will reflect the influence of past policies and incentives in various ways. To the extent that these policies have been targeted on low-income households, either by grants and financial incentives or through direct provision and intervention in certain parts of the housing stock predominantly occupied by lower- income households, they may have succeeded in eliminating income-related differences in the pattern of possession of energy efficiency measures that would otherwise have existed.

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